



What is Claimed:

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- 1 A method for laser welding a first foil to a second foil, the method comprising the steps of:
- a) providing the first foil having a first thickness and the second foil
 having a second thickness, the second thickness being less than about 150% of the
 first thickness;
- b) positioning at least a portion of a bottom surface of the first foil in contact with at least a portion of a top surface of the second foil;
 - c) producing a beam spot on a top surface of the first foil using a laser welding system, at least a central region of the beam spot having sufficient fluence to form a melt pool that extends from the top surface of the first foil to the bottom surface of the first foil; and
 - d) scanning the laser beam spot along a weld line of the top surface of the first foil to weld the first foil to the second foil along the weld line.
- 2. A method according to claim 1, wherein step (a) includes the steps of:
- a1) providing the first foil formed of at least of steel, aluminum,
 copper, gold, silver, molybdenum, tungsten, iron, tantalum, nickel, a polymer material,
 or a plastic material;
 - a2) providing the second foil formed of at least of steel, aluminum, copper, gold, silver, molybdenum, tungsten, iron, tantalum, nickel, a polymer material, or a plastic material.
- 3. A method according to claim 1, wherein step (b) further includes the step of positioning a thermally conductive top-plate in contact with the top surface of the first foil proximate to the weld line.
- 4. A method according to claim 1, wherein step (c) includes the steps of:
- generating a continuous wave laser beam, the continuous wave laser beam having a predetermined wavelength and a welding power; and
- 5 c2) focusing the continuous wave laser beam to the beam spot on the 6 top surface of the first foil having a welding spot size.
 - 5. A method according to claim 4, wherein:

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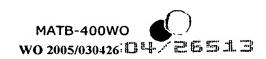
step (c2) includes coupling the continuous wave laser beam into a fiber-2 3 coupled laser head; and

- step (d) includes moving the fiber-coupled laser head parallel to the top surface of the first foil to scan the beam spot along the weld line.
- 6. A method according to claim 4, wherein step (d) includes scanning the beam spot along the weld line at a welding slew rate. 2
- 1 7. A method according to claim 6, wherein step (d) includes one of:

moving the first foil and the second foil at the welding slew rate so that 2 the beam spot is scanned along the weld line on the top surface of the first foil; or 3

moving the beam spot at the welding slew rate so that the beam spot is 4 scanned along the weld line on the top surface of the first foil. 5

- 8. A method according to claim 6, wherein step (d) includes the 1 steps of: 2
- detecting a temperature of the first foil proximate to the weld d1) 3 line; and 4
- d2) varying the welding slew rate based on the temperature detected 5 in step (d1). 6
 - 9. A method according to claim 6, wherein:
- the weld line extends from a first edge of the first foil to a second edge of 2 the first foil; 3
- step (d) includes varying the slew rate in portions of the weld line 4 proximate to the first edge of the first foil and the second edge of the first foil. 5
- A method according to claim 4, wherein step (c1) includes the 10. t steps of: 2
- detecting a temperature of the first foil proximate to the weld. c1a) 3 line; and
- varying at least one of the welding power and the welding spot 5 size based on the temperature detected in step (c1a). 6
- A method according to claim 4, wherein: 11. l
- the weld line extends from a first edge of the first foil to a second edge of 2 3 the first foil;





4	step (c1) includes varying at least one of the welding power and the					
5	welding spot size in portions of the weld line proximate to the first edge of the first foil					
6	and the second edge of the first foil.					
1	12. A method according to claim 1, wherein:					
2	step (b) includes at least one of:					
3	placing the first foil and the second foil in a process gas; or					
4	blowing the process gas over the at least a portion of the first foil					
5	proximate to the beam spot; and					
6 7	the process gas is selected to reduce ambient chemical reactions of a material of the first foil during laser welding.					
l 2	13. A method according to claim 12, wherein the process gas includes at least one of nitrogen, carbon dioxide, or a noble gas.					
i 2	14. A system for laser welding a plurality of foils arranged in a stack, the system comprising:					
3	a continuous wave laser for generating a laser beam;					
4	optics for focusing the laser beam to a beam spot;					
5 6 7 8	a foil holder including a thermally conductive plate that includes a continuous edge, the thermally conductive plate placed in contact with a top surface of a first foil of the plurality of foils to hold the plurality of foils such that the continuous edge is proximate to a weld line; and					
9 0	a movement stage for scanning the beam spot of the laser beam along the weld line at a welding slew rate by moving at least one of;					
1	the foil holder and the plurality of foils; or					
2	the optics.					
1	15. A system according to claim 14, wherein the foil holder further					
2	includes:					
3	a temperature sensor thermally coupled to at least one of the plurality of foils for sensing a foil temperature proximate to the weld line; and					
5 6	a controller for varying one or more of the welding slew rate and a powe of the laser beam responsive to the foil temperature.					
1	16. A system according to claim 15, wherein:					

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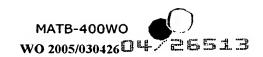
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2	the thermally conductive plate includes a void proximate to the				
3	continuous edge; and				
4	the temperature sensor includes a thermocouple placed within the void.				
i	17. A system according to claim 14, wherein the continuous edge of				
2	the thermally conductive plate is sloped at an acute angle relative to the top surface of				
3	the first foil sloping away from the weld line.				
1	18. A system according to claim 14, wherein the optics include an				
2	optical fiber and an output laser head.				
1	19. A system according to claim 18, the movement stage includes an				
2	arm for positioning the output laser head such that the beam spot of the laser beam is				
3	focused and scanned along the weld line from a predetermined position relative to the				
4	first foil.				
ı	20. A system according to claim 14, wherein the continuous wave				
2	laser is a high power direct diode laser operated at a wavelength of approximately				
3	808nm and a power of between about 150 and 200 watts.				
l	21. A system according to claim 14, wherein the continuous wave				
2	laser is operated at a wavelength selected to be substantially absorbed by the first foil.				
ì	22. A system according to claim 21, wherein the continuous wave				
2	laser is operated at a wavelength selected to be substantially reflected by the				
3	continuous edge of the thermally conductive plate.				
ı	23. A system according to claim 14, further comprising a process gas				
2	injector for one or more of:				
3	blowing a process gas over the weld line in a region including the beam				
4	spot; or				
5	surrounding the plurality of foils with the process gas.				
ı	24. A system according to claim 14, wherein the plurality of foils				
2	include at least one of steel, aluminum, copper, gold, silver, molybdenum, tungsten,				
3	iron, tantalum, nickel, a polymer material, or a plastic material.				

A system according to claim 14, wherein the thermally conductive 25. plate includes at least one of copper, ceramic, or alumina.

> 26. A system according to claim 14, wherein:





2	a body of the thermally conductive plate is substantially formed of				
3	copper; and				
4	the continuous edge of the thermally conductive plate is substantially				
5	formed of alumina.				
l	27. A method for laser welding a first foil to a second foil, the method				
2	comprising the steps of:				
3	a) providing the first foil having a first thickness and the second foil				
4	having a second thickness;				
5	b) positioning at least a portion of a bottom surface of the first foil in				
6	contact with at least a portion of a top surface of the second foil;				
7	c) positioning a thermally conductive plate including a continuous				
8	edge, a bottom surface of the thermally conductive plate being in contact with at least				
9	a portion of a top surface of the first foil;				
	d) producing a beam spot on the top surface of the first foil using a				
0	laser welding system, at least a central region of the beam spot having sufficient				
2	fluence to form a melt pool that extends from the top surface of the first foil to the				
3	bottom surface of the first foil; and				
	e) scanning the laser beam spot along a weld line of the top surface				
4 5	of the first foil to weld the first foil to the second foil along the weld line, the weld line				
6	being proximate to the continuous edge of the thermally conductive plate.				
	28. A method according to claim 27, wherein the first thickness is				
1 2	greater than or equal to the second thickness.				
2					
1	29. A method according to claim 27, wherein:				
2	step (a) further includes providing a third foil having a third thickness;				
3	step (b) further includes positioning at least a portion of a bottom surface				
4	of the second foil in contact with at least a portion of a top surface of the third foil; and				
5	the sum of the second thickness and the third thickness being less than				
6	about 150% of the first thickness.				
1	30. A method according to claim 27, wherein step (a) includes the				
2	steps of:				

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3		a1)	providing the first foil formed of at least one of steel, aluminum,			
4	copper, gold, silver, molybdenum, tungsten, iron, tantalum, nickel, a polymer material,					
5	or a plastic material;					
6		a2)	providing the second foil formed of at least one of steel,			
7	aluminum, cop	pper, g	old, silver, molybdenum, tungsten, iron, tantalum, nickel, a			
8	polymer mate	rial, or	a plastic material.			
i		31.	A method according to claim 27, wherein step (d) includes the			
2	steps of:					
3		d1)	generating a continuous wave laser beam, the continuous wave			
4	laser beam ha	ving a	predetermined wavelength and a welding power; and			
5		d2)	focusing the continuous wave laser beam to the beam spot on the			
6	top surface of the first foil having a welding spot size.					
1		32.	A method according to claim 29, wherein:			
2		step (d2) includes coupling the continuous wave laser beam into a fiber-				
3	coupled laser head; and					
4		step (e	e) includes moving the fiber-coupled laser head parallel to the top			
5	surface of the first foil to scan the beam spot along the weld line.					
ı		33.	A method according to claim 29, wherein step (e) includes			
2	scanning the l	beam s	pot along the weld line at a welding slew rate.			
ı		34.	A method according to claim 33, wherein step (d) includes one of:			
2		movin	g the first foil, the second foil, and the thermally conductive plate			
3	at the welding slew rate so that the beam spot is scanned along the weld line on the					
4	top surface of	the fir	st foil; or			
5		movin	g the beam spot at the welding slew rate so that the beam spot is			
6	scanned along	the w	eld line on the top surface of the first foil.			
1		35.	A method according to claim 33, wherein step (e) includes the			
2	steps of:					
3		e1)	detecting a temperature of the first foil proximate to the weld			
4	line; and					
5		e2)	varying the welding slew rate based on the temperature detected			
6	in step (e1).	-				

A method according to claim 33, wherein:



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2		the we	eld line extends from a first edge of the first foil to a second edge of		
3	the first foil;				
4		step (e	e) includes varying the slew rate in portions of the weld line		
5	proximate to the first edge of the first foil and the second edge of the first foil.				
1		37.	A method according to claim 29, wherein step (d1) includes the		
2	steps of:				
3		d1a)	detecting a temperature of the first foil proximate to the weld		
4	line; and				
5		d1b)	varying at least one of the welding power and the welding spot		
6	size based on the temperature detected in step (d1a).				
ì		38.	A method according to claim 29, wherein:		
2		the we	eld line extends from a first edge of the first foil to a second edge of		
3	the first foil;				
4		step (d	d1) includes varying at least one of the welding power and the		
5	welding spot size in portions of the weld line proximate to the first edge of the first foil				
6	and the secor	nd edge	of the first foil.		
ı		39.	A method according to claim 27, wherein:		
2	step (b) includes at least one of:				
3			placing the first foil and the second foil in a process gas; or		
4			blowing the process gas over the at least a portion of the first foil		
5	proximate to the beam spot; and				
6		the pr	ocess gas is selected to reduce ambient chemical reactions of a		
7	material of th	e first f	oil during laser welding.		
ı		40.	A method according to claim 39, wherein the process gas includes		
2	at least one of nitrogen, carbon dioxide, or a noble gas.				